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FINAL REPORT

Assessment of Geology, Energy, and Minerals (GEM) Resources

NORTH FORK CROOKED RIVER GEM RESOURCE AREA

(OR-050-12)

CROOK COUNTY, OREGON

Prepared for

United States Department of the Interior
United States Bureau of Land Management
Scientific Systems Development Branch

March 1983

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North Fork Crooked River GRA
(OR - 050 - 12)
Crook County, Oregon

Prepared For:

United States Department of the Interior
United States Bureau of Land Management
Scientific Systems Development Branch

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BLM Contract No.: YA - 553 - CT2 - 1042

March, 1983

This report was prepared as part of a Phase I Assessment of GEM Resources within designated Wilderness Study Areas in Oregon, Idaho and Nevada.

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All members of the panel of experts provided valuable input into these assessments of GEM resources for each of the GEM Resource Areas (GRAs). Their professional approach to the problems and their interpretations of available literature and data form the foundation upon which the assessments for this project are based. We are grateful for their efforts and skills in this project. The panelists and their area of expertise are:

- Dr. Antonius Budding - Oil Shale and Tar Sands
- Mr. Raymond Corcoran - Field Verification
- Dr. James Firby - Paleontology
- Mr. Ralph Mason - Coal
- Mr. Richard Miller - Uranium and Thorium
- Mr. Vernon Newton - Oil and Gas
- Mr. Herbert Schlicker - Industrial Minerals and Geologic Hazards
- Dr. Walter Youngquist - Geothermal
- Dr. Paul Weis - Metals and Non - Metals.

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Mr. Tom Mitchell assisted in the stream sediment sampling program. Bondar - Clegg provided the geochemical analysis of stream sediment samples.

Ms. Pamela Ruhl provided clerical and editorial assistance throughout the project. Ms. Sara Mathews assisted with occurrence information and drafting. Mr. Philip R. Jones and Mr. Michael A. Becker produced all documents relating to the project using TERRADATA's word processing and document production systems.

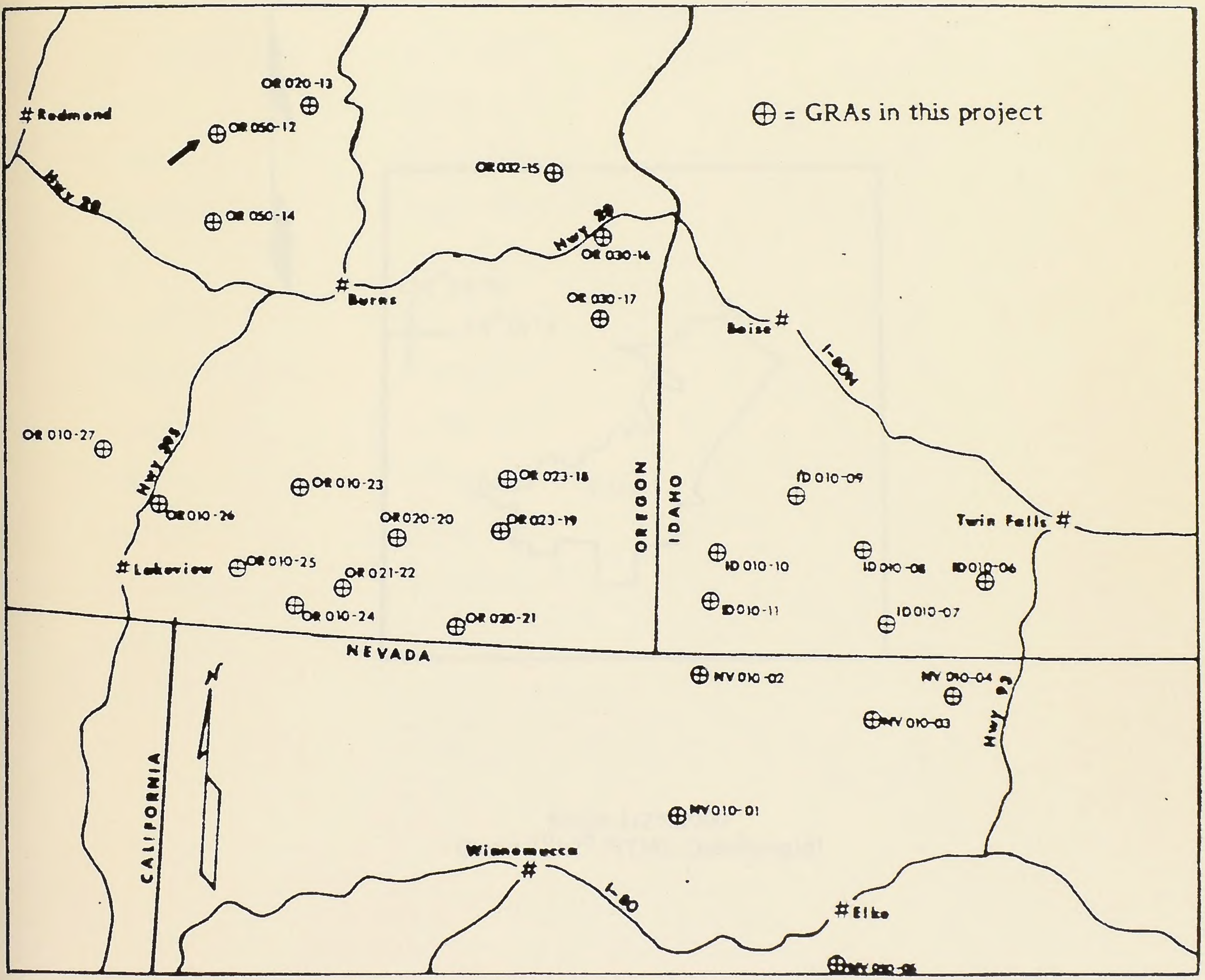
EXECUTIVE SUMMARY

The purpose of this project is to evaluate and classify environments favorable for the occurrence of GEM resources in southeastern Oregon, southwestern Idaho, and northern Nevada. **(See the TERRADATA report entitled "Procedures for the Assessment of Geology, Energy, and Minerals (GEM) Resources.")** GEM resource environments have been rated on a scale that ranges from one to four, with one being least favorable and four being most favorable. Favorability classes two and three represent low and moderate favorability, respectively. Confidence levels range from A to D with A being low confidence and D being high confidence. The confidence levels are directly related to the quantity and quality of the information available for the determination of the favorability classes.

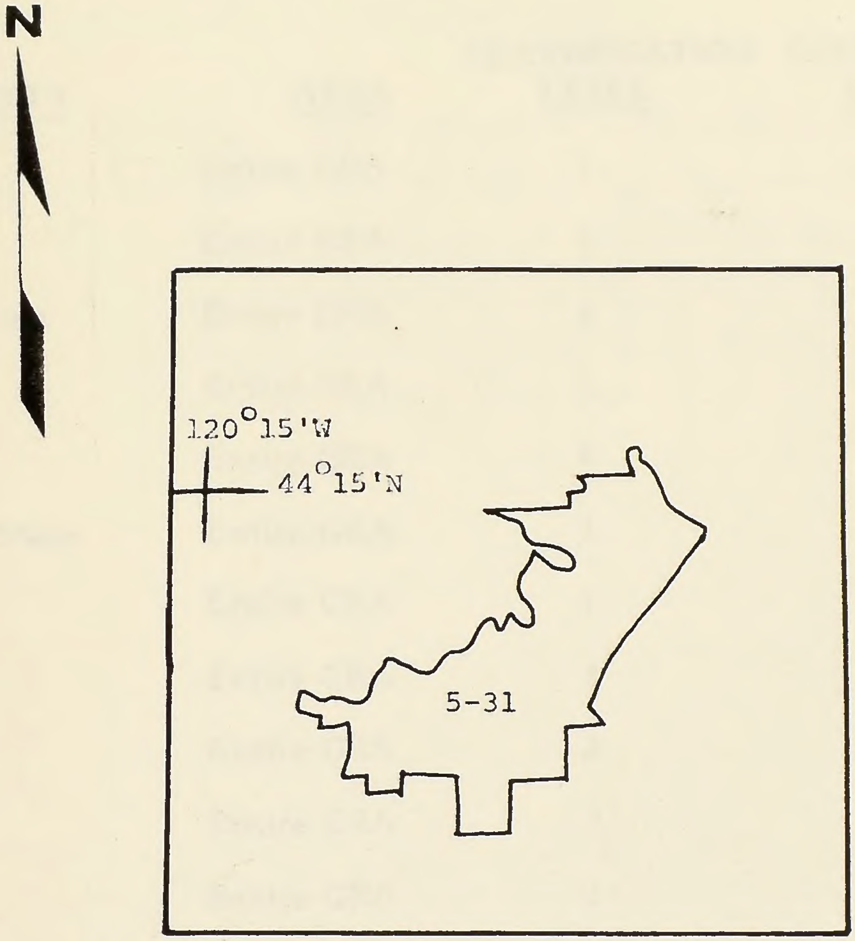
The specific area with which this report deals is the North Fork Crooked River GEM resource area (GRA OR-050-12) which is located in central Oregon (see attached location map). The GRA contains about 144 square miles within Townships 15S and 16S and Ranges 21E and 22E. It contains one WSA (WSA 5-31) which comprises 10,745 acres. The study area is in the Central Oregon Resource Area of the Prineville BLM District. It is about 30 miles from Prineville, Oregon.

The GRA is within the Blue Mountains sub-province of the Central Highland physiographic province. Paleozoic eugeoclinal sediments may occur at depth. However only Tertiary volcanogenic units and Quaternary deposits are exposed within the study area. The majority of the area is underlain by the Tertiary Picture Gorge Basalt. The major structural element in the area is the Columbia Arc and associated Columbia Embayment. The North Fork Crooked River GRA contains several geologic environments that are variously favorable for GEM resources. The study area is classified 4C for the occurrence of oil and gas resources. The 4C rating signifies that the geologic environment, the inferred geologic processes and the reported mineral occurrences indicate high favorability for the occurrence of oil and gas, and that the available data provide direct evidence but are quantitatively minimal to support the existence of oil and gas. The study area also contains environments similar to those found in other Tertiary basins in which clinoptilolite and bentonite deposits occur. The classification of the area for potential clinoptilolite and bentonite resources (3A and 3B respectively) signifies that although the necessary geologic environment is believed to be present, there is little or no evidence to support or refute this evaluation.

GRA Location Map



Land Classification Map
North Fork Crooked River GRA
(OR - 050 - 12)
Crook County, Oregon



Scale 1:250,000
(Bend 1°x2° NTMS Quadrangle)

Classification Of Lands Within The North Fork Crooked River GRA

(OR - 050 - 12)

Crook County, Oregon

For GEM Resource Potential

COMMODITY	AREA	CLASSIFICATION LEVEL	CONFIDENCE LEVEL	REMARKS
Metals	Entire GRA	1	B	
Geothermal	Entire GRA	1	C	
Uranium/Thorium	Entire GRA	1	A	
Coal	Entire GRA	1	B	
Oil and Gas	Entire GRA	4	C	
Tar Sands/Oil Shale	Entire GRA	1	C	
Limestone	Entire GRA	1	B	
Bentonite	Entire GRA	3	B	
Diatomite	Entire GRA	2	C	
Clinoptilolite	Entire GRA	3	A	
Paleontology	Entire GRA	2	C	
Hazards	See Hazards Map (GRA File)			
ESLs	None	1	C	

LEGEND:
Class 1 - Least Favorable
Class 2 - Low Favorability
Class 3 - Moderate Favorability
Class 4 - High Favorability

Confidence Level A - Insufficient data or no direct evidence
Confidence Level B - Indirect evidence available
Confidence Level C - Direct evidence but quantitatively minimal
Confidence Level D - Abundant direct and indirect evidence

The entire GRA is favorable (Class 2) for diatomite and paleontological resources (see attached table). The potential for paleontological resources is classified 2A primarily because of proximity to the John Day fossil beds. Diatomite favorability (2C) is based on the favorability of analogous Tertiary sequences in other areas. The area does not exhibit favorable characteristics for other GEM resources.

TERRADATA recommends that further surface geologic investigations be undertaken in the North Fork Crooked River GRA in order to increase confidence levels in the classifications. Detailed geologic mapping and geochemical investigations would be useful in upgrading the resource potential classification of this area. Selective drilling of geochemical and/or geophysical anomalous areas would contribute to the refinement of the confidence level and favorability rating in this GRA.

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1. INTRODUCTION

This report is one of 27 GRA technical reports that summarize the results of a Phase 1 assessment of the geology, energy, and minerals (GEM) resources in selected portions of southeastern Oregon, southwestern Idaho, and northern Nevada. The study region was subdivided into 27 GEM resource areas (GRAs), principally for ease of data management and interpretation. The assessment of GEM resources for this project consisted of an interpretation of existing literature and information by experts knowledgeable in both the geographic area and specific commodities. It is possible that the assessment would be different if detailed field exploration, geochemical sampling, and exploratory drilling programs were undertaken. (See the TERRADATA report entitled "Procedures for the Assessment of Geology, Energy, and Minerals (GEM) Resources.")

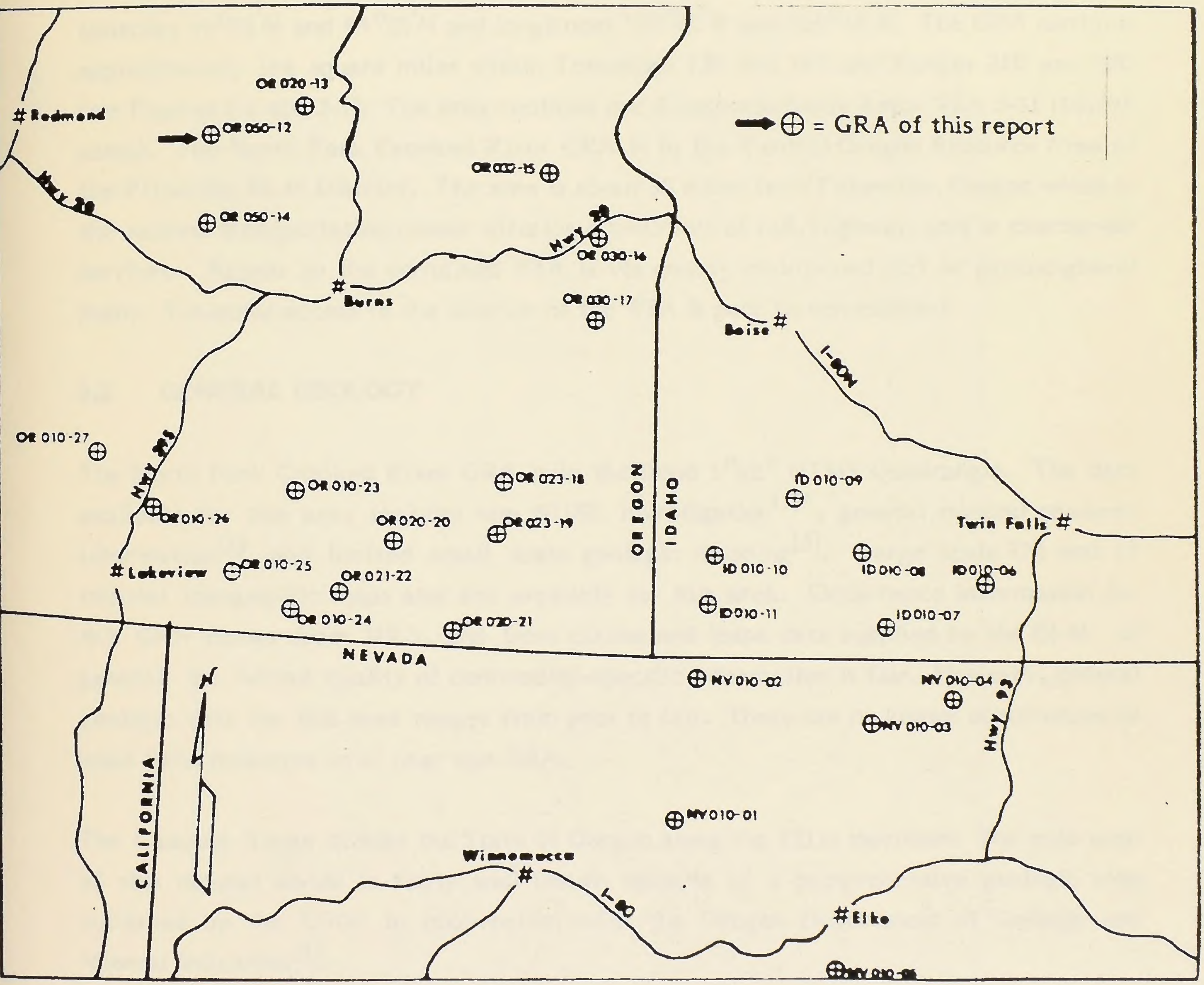
This report summarizes the assessment of the GEM resources potential of the North Fork Crooked River GRA (OR-050-12). See Figure 1-1. Commodity categories for which this GRA was evaluated are:

- Metals
- Oil and Gas
- Oil Shale and Tar Sands
- Geothermal
- Uranium and Thorium
- Coal
- Industrial Minerals
- Paleontological Resources
- Geologic Hazards
- Educational and Scientific Localities (ESLs)

Geologic environments within the North Fork Crooked River GRA have been rated with respect to their favorability for the occurrence of these different commodities. The favorability rating scale ranges from one to four, with one being least favorable and four being most favorable. Confidence levels in these ratings also have been assigned. These confidence levels range from A to D, with A being low confidence and D high confidence. Assigned confidence levels are related to the quantity and quality of the information available for the determination of the favorability ratings.

FIGURE 1-1

GRA Location Map



2. DESCRIPTION OF THE NORTH FORK CROOKED RIVER GRA

2.1 LOCATION

The North Fork Crooked River GRA (OR-050-12) is in central Oregon. It lies between latitudes 44°08'N and 44°20'N and longitudes 120°00'W and 120°16'W. The GRA contains approximately 144 square miles within Townships 15S and 16S and Ranges 21E and 22E (see Figures 1-1 and 2-1). The area contains one Wilderness Study Area; WSA 5-31 (10,745 acres). The North Fork Crooked River GRA is in the Central Oregon Resource Area of the Prineville BLM District. The area is about 30 miles from Prineville, Oregon which is the nearest transportation center offering a minimum of rail, highway, and/or charter-air services. Access to the contained WSA is via county maintained dirt or packed-gravel roads. Vehicular access to the interior of the WSA is poor to non-existent.

2.2 GENERAL GEOLOGY

The North Fork Crooked River GRA is in the Bend $1^{\circ}x2^{\circ}$ NTMS Quadrangle. The data available for this area includes one NURE investigation(1)*, general mineral resource information(2), and limited small scale geologic mapping(3). Large scale (7½ and 15 minute) topographic maps also are available for this area. Occurrence information for this GRA comes from MILS, and from claims and lease data supplied by the BLM. In general, the overall quality of commodity-specific information is fair. However, general geologic data for this area ranges from poor to fair. There are no known occurrences of most GEM resources in or near this GRA.

The Cascade Range divides the State of Oregon along the 121st meridian. The area west of this natural divide is fairly well known because of a comprehensive geologic map published by the USGS in cooperation with the Oregon Department of Geology and Mineral Industries(3).

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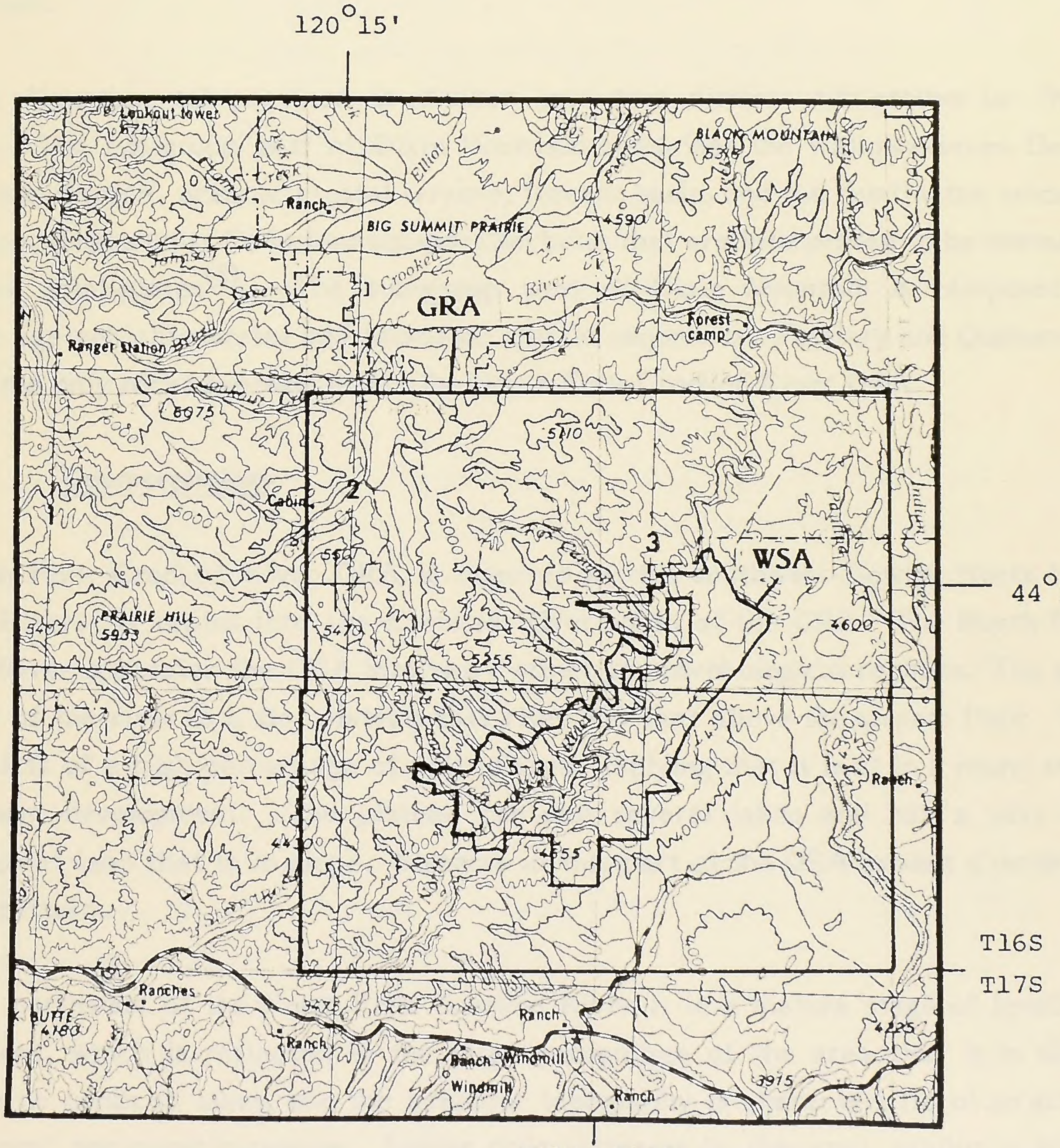
* In this report, citations are superscripted numbers. They refer to bibliographic entries listed in Appendix A, References Cited.

FIGURE 2-1

Topographic Map
North Fork Crooked River GRA
(OR-050-12)
Crook County, Oregon



Scale 1:250,000
(Bend 1°x2° NTMS Quadrangle)

The North Fork Crooked River GRA is within the Blue Mountain sub-province of the Central Highland physiographic province(4). The area is typified by faulted synclinal basins and adjacent monoclinal mountain ranges. The Blue Mountain region includes, from east to northeast, the Ochoco, Strawberry, Greenhorn, Elkhorn, Wallowa, and Blue Mountains. Maximum relief is nearly 8,000 feet, but local relief varies from 2,000 feet to 5,000 feet.

The Blue Mountain sub-province is divided into two distinct sub-groups by Dixie Mountain. The sub-group east of Dixie Mountain comprises the Wallowa-Seven Devils volcanic arc terrane, oceanic crustal terrane, forearc basin, and the Huntington volcanic arc terrane. These units lie in four sub-parallel belts that are interpreted to be remnants of acreted mini-plates(5). The sub-group west of Dixie Mountain is composed of Paleozoic age ophiolite series and Mesozoic clastic sequences. Tertiary and Quaternary units are the only rocks exposed within the North Fork Crooked River GRA.

2.2.1 Geomorphology

The North Fork Crooked River GRA is disected by the southwest-flowing North Fork Crooked River. It drains into the Crooked River south of the GRA. The North Fork Crooked River separates the GRA into two distinct geomorphological regimes. The area southeast of the river is a flat plateau that rises 300 feet above the stream floor. This area consists of a high percentage of upland area, implying that it is at in a young stage of landform development. The plateau contains several lakes and has a very low percentage of land that is in slope. Streams in this part of the GRA exhibit a dendritic drainage pattern.

The area northwest of the North Fork Crooked River is in a mature stage of landform development, which is reflected in the large percentage of the area that is in slope. There are no ponds or lakes, and the irregular topography is characteristic of an active degredational geomorphic regime. Lower order streams in this area exhibit a trellis drainage pattern.

Total relief in this area ranges from a high point of 6,753 feet in the northwest part of the area, near Round Mountain, to the lowest point, 3,475 feet, near the confluence of the Crooked River and the North Fork Crooked River. Local relief in the North Fork Crooked River GRA is 400 feet.

Although published maps of the area do not show any faults, LANDSAT imagery(6) and stratigraphy suggest that the area may contain numerous faults.

2.2.2 Lithology and Stratigraphy

Three broad categories of Tertiary rocks occur within the North Fork Crooked River GRA(5). The first, and most common includes ferromagnesian-rich extrusive and intrusive rocks. The Tertiary Picture Gorge Basalt is a series of ferromagnesian-rich flood basalts that cover nearly 80 percent of the GRA.

Tertiary volcaniclastic lithologies, including tuffs, palagonitic tuff, siltstones, sandstones, and conglomerates are exposed in the south-central part of the GRA. These rocks are the second most common lithologic variety in the study area. They are principally of lacustrine and fluvial origin.

Felsic volcanics comprise the third broad lithologic variety in the North Fork Crooked River GRA. These rocks include the John Day and Clarno Formations and other Tertiary silicic ash-flow tuffs. The John Day and Clarno Formations consist of rhyolite flows and domes, and andesitic flows and volcaniclastic strata, respectively. Both formations are best known for their paleontological assemblages. Fossil-bearing facies of these units are not known to occur within the GRA.

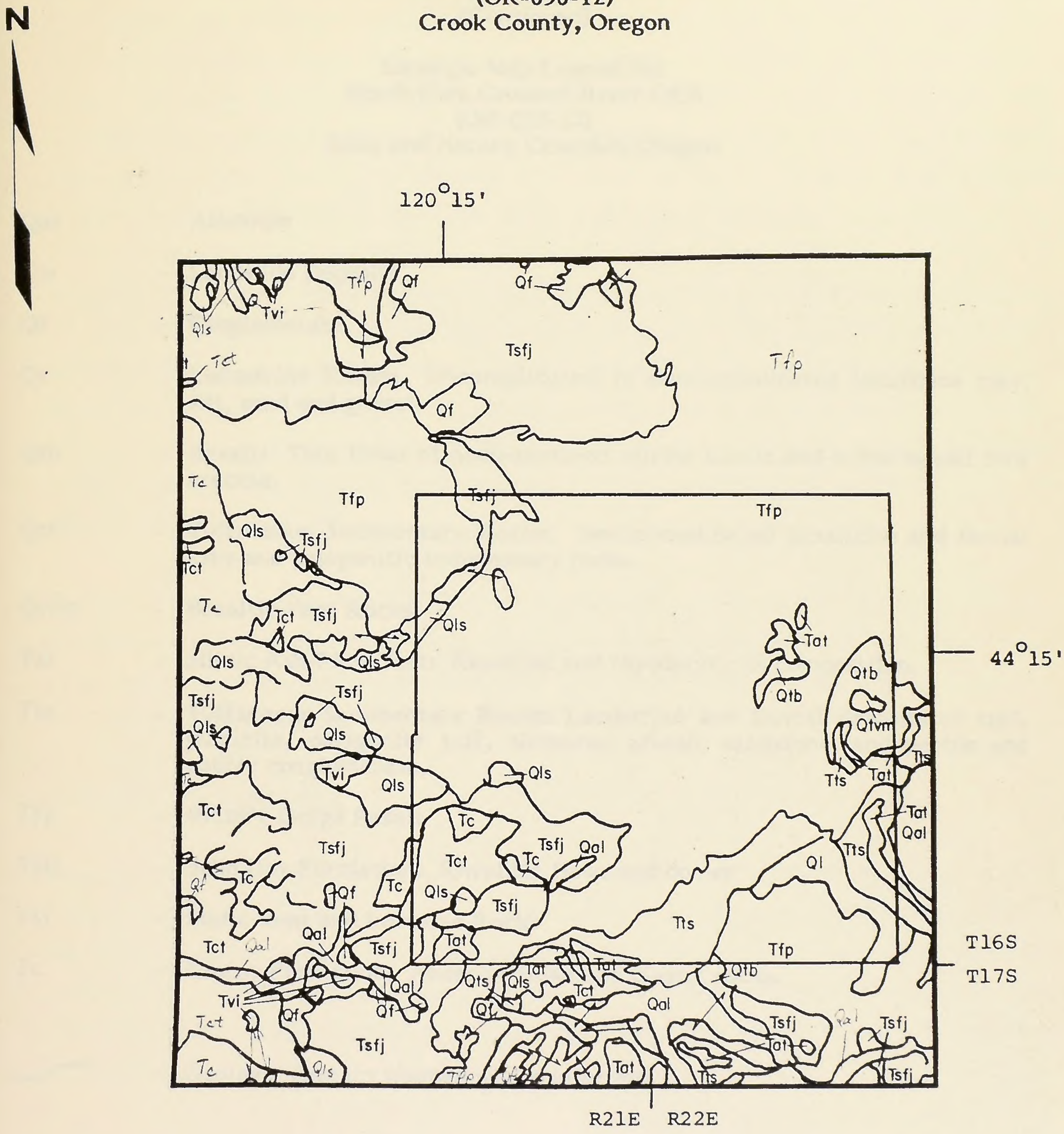
Quaternary units within or near the GRA include basalts, basaltic vent rocks, tuffaceous sedimentary rocks, and lacustrine, fluvial, and landslide deposits. Quaternary basaltic units consist of vent rocks, thin flows of alkaline olivine basalt, and flow breccias that are exposed along the eastern edge of the GRA.

2.2.3 Structural Geology

Major structural events that affected Oregon include orogenic episodes and extensional movements accompanied by outpourings of flood basalts. The latter have obscured much of the earlier geologic history in the area. Devonian sedimentation reflects a near-shore marine environment. During the Pennsylvanian, this part of Oregon was mantled by regressive sandstones of the Spotted Ridge Formation in response to the Antler orogenic event that occurred farther south in Nevada.

FIGURE 2-2

Geologic Map
North Fork Crooked River GRA
(OR-050-12)
Crook County, Oregon



Scale 1:250,000
(Bend 1°x2° NTMS Quadrangle)

FIGURE 2-2
(Continued)

Geologic Map Legend For North Fork Crooked River GRA
(OR-050-12)
Lake and Harney Counties, Oregon

Qal - Alluvium

Qls - Landslide Deposits

Qf - Fanglomerate

Ql - Lacustrine Rocks: Unconsolidated to semiconsolidated lacustrine clay, silt, sand and gravel.

Qtb - Basalt: Thin flows of open-textured olivine basalt and minor basalt flow breccia.

Qts - Tuffaceous Sedimentary Rocks: Semiconsolidated lacustrine and fluvial ashy and palagonitic sedimentary rocks.

Qtvm - Basaltic Vent Rocks

Tat - Silicic Ash-Flow Tuff: Rhyolitic and rhyodacitic in composition.

Tts - Tuffaceous Sedimentary Rocks: Lacustrine and fluvial deposits of tuff, pumicite, palagonite tuff, siltstone, arkosic sandstone, and pebble and cobble conglomerate.

Tfp - Picture Gorge Basalt

Tsfj - John Day Formation: Rhyolitic flows and domes

Tvi - Mafic Vent and Intrusive Rocks

Tc - Clarno Formation: Andesite flows and clastic rocks.

— - Geologic contact (dashed where inferred).

Episodes of mini-plate acretions occurred during the Permian and Triassic in the eastern Blue Mountains, resulting in four sub-parallel belts of oceanic and forearc basin rocks. The Late Jurassic to Early Cretaceous orogenic event is characterized in southwestern Oregon by strong folding, faulting, and regional metamorphism. Ultramafic bodies that are associated with the Idaho Batholith were emplaced at this time. This event was significant in that it was the driving mechanism for the concentration of valuable mineral deposits that occur in the Dixie Butte gold area in the Aldrich Mountains.

A eugeocline formed in the Middle to Late Mesozoic. This structure was the repository for tens of thousands of feet of Triassic and Jurassic sediments that are potentially favorable for the accumulation of oil and gas. Nevadan and Laramide orogenies at the end of the Mesozoic rotated this structure, forming what is now known as the Columbia Arc. At about the same time, the Klamath Mountains were thrust westward. Stratigraphic offsets suggest that rotation of the Columbia Arc continued into the Oligocene(5).

In eastern Oregon, northwest trending fault patterns resulted from extensional faulting similar to that in the Basin and Range Province. Some faults, such as the Brothers fault zone, can be seen to curve more northward near Bend, Oregon. This may be related to the rotational movements of the Columbia Arc.

2.2.4 Paleontology

The dominant lithology in the North Fork Crooked River GRA is the Late Tertiary Picture Gorge Basalt which may contain fossils only in lacustrine environments of restricted lateral extent. Tuffaceous sedimentary facies within other Tertiary units (specifically the Clarno Formation) may contain vertebrate remains(7). The John Day Formation occurs within the GRA, but consists primarily of rhyolitic flows and domes in this area.

2.2.5 Historical Geology

The evolutionary history of this area during Paleozoic and Early Mesozoic time is incompletely known because of the paucity of exposures. Devonian, Late Mississippian, and Permian limestones and shales suggest a transgressive-regressive sequence that developed in warm epirogenic to marginal basin seas. These strata were subsequently

folded and faulted in Early Mesozoic time. Dynamothermal metamorphism and syntectonic intrusions further obscured the previous geologic history of these strata.

The eroded roots of these Early Mesozoic structures are unconformably overlain by Late Triassic and Jurassic strata; this portion of Oregon was being actively eroded during Late Paleozoic and Early Mesozoic.

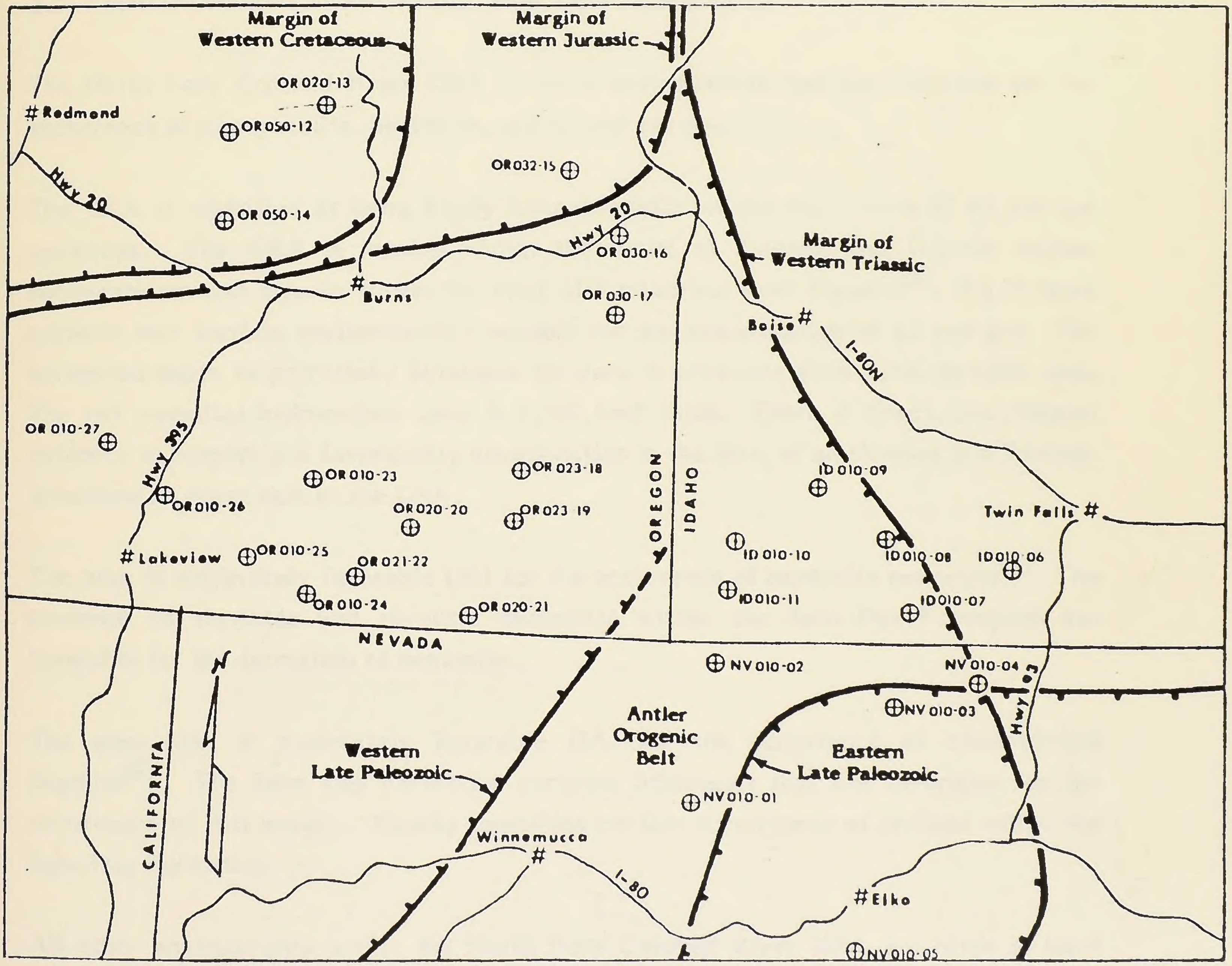
The Late Mesozoic and Cenozoic history of the area is much more clear. Two major tectonic features formed during this time. There were the Columbia Arc, which consisted of Paleozoic and Mesozoic rocks, and the Columbia Embayment, which was the locus of Cenozoic sedimentation and volcanic activity. The Columbia Embayment was a eugeoclinal trench that developed between the Klamath and Wallowa Mountains. Thousands of feet of graywacke, lava flows, and volcaniclastic sediments were deposited in the Columbia Embayment. There was nearly continuous volcanism in the southwestern part of this trough. This is reflected in the thick sequence of volcanics near Willowdale and Ashwood(5). Conversely, the northeastern part of the trough received only intermittent volcanics. Limestone reefs formed in this area during episodes of diminished volcanic activity.

Upper Triassic and Jurassic strata compose fluvial, conglomerate, sandstones, siltstones and mudstones, and freshwater limestones. Some red beds occur in Silvies River Canyon. The Hyde Formation of the Izee Group represents a minor marine transgression; it contains as much as 1,000 to 1,500 feet of marine sediments. The Mesozoic strata were subsequently folded and faulted during the Late Jurassic to Early Cretaceous orogenic event. Syntectonic intrusives and regional metamorphism accompanied this event. Most of the metalliferous mineralization in this part of Oregon is related to these intrusives.

The geologic evolution of Oregon was characterized by continued uplift and volcanism during Cenozoic time. In western Oregon volcanics filled the remaining geoclines. Sporatic eruptions of basalt and rhyolite in the Paleocene dammed streams and filled basins in central Oregon. Central and western Oregon were blanketed by lava flows and pyroclastic deposits from the emerging Cascades. In the Miocene, basalt flows in northern Oregon and nearby areas covered tens of thousands of square miles, forming the Columbia River Basalt Plateaus. The southern Blue Mountains contained basaltic and rhyolitic volcanoes that eventually inundated them with thick volcanogenic deposits.

FIGURE 2-3

Paleogeographic Map(8)
Oregon-Idaho-Nevada
Tri-State Area



The tropical climate during the Tertiary was conducive to the development of limonitic ore deposits and lateritic bauxites on the flat basaltic plateaus in western Oregon. By Pliocene time, nearly all of Oregon was above sea-level and the climatic differentiation became more pronounced as a result of further development of the Cascades. Development of the present Blue Mountains was completed.

2.3 ENVIRONMENTS FAVORABLE FOR GEM RESOURCES

The North Fork Crooked River GRA contains environments that are favorable for the occurrence of clinoptilolite, bentonite, and oil and gas resources.

The GRA is classified as being highly favorable (4C) for the occurrence of oil and gas resources. The GRA is located within the limits of Jurassic and Triassic marine sedimentation and may be within the limit of Cretaceous shelf deposits(8). All of these systems may contain environments favorable for the accumulation of oil and gas. The estimated depth to potentially favorable horizons is anywhere from 6,000 to 8,000 feet. The net potential hydrocarbon zone is 1,500 feet thick. There is direct, but minimal evidence to support this favorability classification in the form of an oil-seep in a Jurassic limestone 20 miles east of the GRA.

The area is moderately favorable (3B) for the occurrence of bentonite resources(6). The presence of rhyolites and rhyolitic sediments within the John Day Formation are favorable for the formation of bentonite.

The area also is moderately favorable (3A) for the occurrence of clinoptilolite deposits(6). The John Day Formation contains lithologics that are favorable for the occurrence of this zeolite. Nearby townships contain occurrences of zeolites within the John Day Formation.

All other environments within the North Fork Crooked River GRA are rated as least favorable to only slightly favorable for the occurrence of other GEM resources. The low favorability classifications for resources other than bentonite, clinoptilolite, and oil and gas are based on the fact that the requisite geologic environments are not known to exist and/or the geologic processes essential for the accumulation of mineral resources cannot be demonstrated to have occurred in the area.

2.3.1 Environments for Metals Resources

The North Fork Crooked River GRA contains no environments that are considered favorable for the accumulation of metallic resources(9). Requisite geologic environments and evidence of mineralizing processes do not exist within or near the GRA.

2.3.2 Environments for Oil and Gas Resources

The North Fork Crooked River GRA is highly favorable for the occurrence of oil and gas resources. Potentially favorable environments include Triassic, Jurassic, and Cretaceous marine sedimentary units that underlie the study area(8). Favorability is enhanced by the occurrence of multiple potentially favorable hosts.

2.3.3 Environments for Oil Shale and Tar Sands Resources

The North Fork Crooked River GRA contains no environments that are favorable for the occurrence of oil shale or oil impregnated sand(10). The area is underlain predominantly by Tertiary volcanics of felsic to ferromagnesian composition. Potential sedimentary hosts are largely tuffaceous and contain only minor amounts of non-volcanic clastic material and carbonates. Favorable lithologies are not present.

2.3.4 Environments for Geothermal Resources

The North Fork Crooked River GRA contains no environments that are favorable for geothermal resources. The requisite geologic criteria are not present in the area(11). The topographic criterion is not satisfied because the area has no prominent fault zones; the Tertiary volcanics are not young enough. The Quaternary volcanics do not exhibit any of the geothermal recognition criteria. There is no likelihood that this GRA could contain any geothermal resources.

2.3.5 Environments for Uranium and Thorium Resources

The North Fork Crooked River GRA contains no environments that are favorable for the occurrence of uranium or thorium(12). The GRA does not exhibit any of the lithology, alteration, or geochemical recognition criteria for environments that may be favorable

for uranium or thorium. There are no uranium occurrences in or near the area; and no evidence to indicate the presence of uranium or thorium in association with any other mineralization.

2.3.6 Environments for Coal Resources

The North Fork Crooked River GRA contains low favorability for the occurrence of coal and lignite deposits(13). The chances for coal or carbonaceous materials to have formed in the study area are remote. The geology of the North Fork Crooked River GRA does not support environments favorable for the formation of coal deposits. Much of the area is either mantled with accumulations of lavas and related volcanic products or has been modified by adjacent volcanic activity.

2.3.7 Environments for Industrial Minerals Resources

Rhyolite and rhyolitic lacustrine sediments in the North Fork Crooked River GRA are favorable for the formation of diagenetic bentonite and clinoptilolite(6). These two rock-types are favorable for bentonite and clinoptilolite if the right diagenetic environments were present for their formation. There are known occurrences of clinoptilolite in nearby towhships.

2.3.8 Environments for Paleontological Resources

The North Fork Crooked River GRA contains environments that are favorable for paleontological resources. However, no fossil localities or occurrences are known in the area.

2.3.9 Environments for Geologic Hazards

Potential geologic hazards in the North Fork Crooked River GRA consist of mapped and interpreted faults, landslides, and/or volcanic centers(6). These features were noted from aerial photographs, geologic maps, and topographic maps. There is no historical record of violent seismic or volcanic activity in the area. The potential for mass movement exists along all over-steepened slopes within the GRA.

2.3.10 Educational and Scientific Localities

There are no known ESLs in the North Fork Crooked River GRA.

3. ENERGY AND MINERAL RESOURCES IN THE NORTH FORK CROOKED RIVER GRA

The overall favorability of the North Fork Crooked River GRA for GEM resources is low, with the exception of oil and gas, bentonite, and clinoptilolite.

3.1 KNOWN DEPOSITS

The North Fork Crooked River GRA has no known deposits of GEM resources.

3.2 OCCURRENCES

The North Fork Crooked River GRA contains two MILS localities (Figure 3-1) that represent three sand and gravel explorations. These sand and gravel pits are not located within WSA 5-31. There are no CRIB or NURE occurrences or localities within the GRA.

3.3 CLAIMS

The North Fork Crooked River GRA contains no known claims. Claims data used in this evaluation are current as of 15 August, 1982.

3.4 LEASES

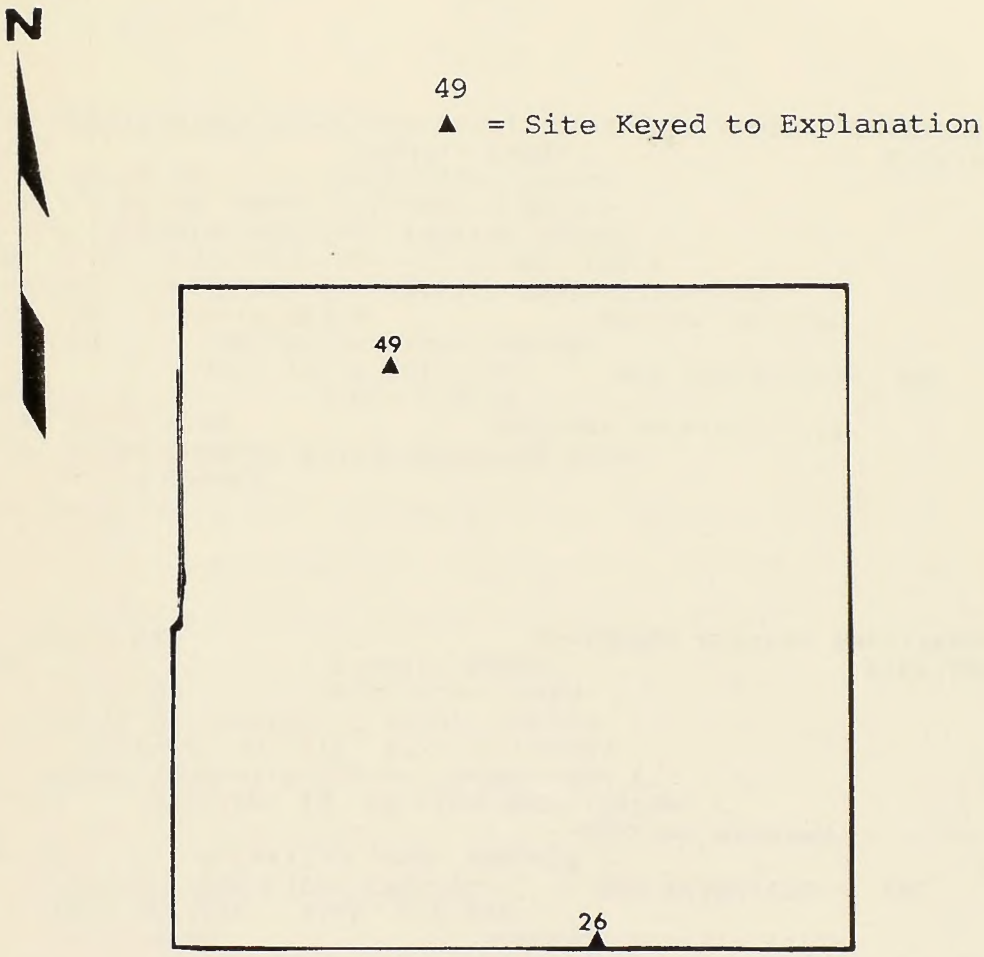
Township 16S and Ranges 21E and 22E are completely leased or are under lease application for oil and gas. This leasing activity covers the southern half of the North Fork Crooked River GRA and includes the southern 70 percent of WSA 5-31. Lease information is current as of 15 August, 1982.

3.5 DEPOSIT TYPES

There are no known deposits within the North Fork Crooked River GRA.

FIGURE 3-1

MILS Localities Map
North Fork Crooked River GRA
(OR 050-12)
Crook County, Oregon



Scale 1:250,000
(Bend $1^{\circ} \times 2^{\circ}$ NTMS Quadrangle)

This map is an overlay for Figures 2-1 and 2-2.

FIGURE 3-1

Explanation For
MILS Localities Map
North Fork Crooked River GRA
(OR 050-12)
Crook County, Oregon

```
   50
26 NAME- UPPER CROOKED RIVER BANK STAB PRJCT  REFERENCE NUMBER- 0410130067
   STATE- OREGON                   COUNTY- CROOK                  ELEV:PREC- 1128M:500M
   LATITUDE-   N 44 08 06         PRECISION-  500M
   LONGITUDE- W 120 06 52  REFERENCE POINT- APPROX
   UTM:  ZONE 10N  NORTHING 4890700  EASTING 730831
   PUBLIC LAND SURVEY  TOWNSHIP- 016 S   RANGE- 022 E
       DESCRIPTION       SECTION- 32  SECTION SUBDIVISION- SW
   RIVER BASIN- 7AG  CROOKED RIVER               DOMAIN- UNKNOWN
   STATUS- PRODUCER          OPERATION TYPE- SURFACE
   MESA ID NO.              YEAR FIELD CHECKED-       MAP REPOSITORY-   FOC
   MAP NAME- BEND                  TYPE- 1:250K
   1:250,000 MAP NAME- BEND                  MINERAL PROPERTY FILE-
   PRIMARY NAME  UPPER CROOKED RIVER BANK STAB PRJCT
   COMMOD MOD-  SAND & GRAVEL
   OR NF
   12 MI S OF PAULINA

   33
49 NAME- JUNGLE CREEK PIT                           REFERENCE NUMBER- 0410130081
   STATE- OREGON                   COUNTY- CROOK                  ELEV:PREC- 1524M:500M
   LATITUDE-   N 44 17 05         PRECISION-  500M
   LONGITUDE- W 120 11 31  REFERENCE POINT- TRENCH
   UTM:  ZONE 10N  NORTHING 4907115  EASTING 724063
   PUBLIC LAND SURVEY  TOWNSHIP- 015 S   RANGE- 021 E
       DESCRIPTION       SECTION- 10  SECTION SUBDIVISION- C
   RIVER BASIN-                                  DOMAIN- UNKNOWN
   STATUS- UNKNOWN           OPERATION TYPE- SURFACE
   MESA ID NO. 05 02735  YEAR FIELD CHECKED-       MAP REPOSITORY-   FOC
   MAP NAME- WILLIAMS PRAIRIE   TYPE- 7.5 MIN
   1:250,000 MAP NAME- BEND                  MINERAL PROPERTY FILE-
   PRIMARY NAME- JUNGLE CREEK PIT
   COMMOD MOD-
   MESA

   84
49 NAME- WIDOW CREEK PIT                            REFERENCE NUMBER- 0410130088
   STATE- OREGON                   COUNTY- CROOK                  ELEV:PREC- 1516M: 10M
   LATITUDE-   N 44 17 27         PRECISION-   5KM
   LONGITUDE- W 120 11 54  REFERENCE POINT- ORE BODY
   UTM:  ZONE 10N  NORTHING 4907777  EASTING 723529
   PUBLIC LAND SURVEY  TOWNSHIP- 015 S   RANGE- 021 E
       DESCRIPTION       SECTION- 10  SECTION SUBDIVISION- NENWNW
   RIVER BASIN- 7AG                              DOMAIN- NAT FOREST
   STATUS- PRODUCER          OPERATION TYPE- SURFACE
   MESA ID NO. 05 02615  YEAR FIELD CHECKED-       MAP REPOSITORY-   FOC
   MAP NAME- WILLIAMS PRAIRIE   TYPE- 7.5 MIN
   1:250,000 MAP NAME- BEND                  MINERAL PROPERTY FILE-
   PRIMARY NAME- WIDOW CREEK PIT
   COMMOD MOD-  SAND & GRAVEL
   MESA
```

3.6 MINERAL ECONOMICS

The North Fork Crooked River GRA is classified as being favorable for the occurrence of oil and gas, bentonite, and clinoptilolite resources.

3.6.1 Oil and Gas

Oil and gas are vitally important to the industrial growth and development of the United States, and to the overall standard of living. Gross supply and demand trends indicate that during the present decade foreign oil will make up at least 45 percent of our national oil requirements. Present domestic production is 8.6 million barrels per day. The United States currently has a 37 million barrel per day equivalent energy demand. It is predicted that by 1990 the United States will produce 8.8 million barrels of oil per day. The equivalent energy demand will increase to 40 million barrels per day(14). During this same period, crude oil demand will decrease by nearly 5 percent, from 16 million barrels per day to 14 million barrels per day equivalent. This decrease is thought to be related to an increase in the use and development of other domestic energy sources, consumer conservation practices, and a predicted slight increase in crude oil production by 1990(14). Because most shallow sources of crude have been or are being depleted, deeper, more difficult targets of oil and gas are being sought. This may result in a rise in the price of crude by 1990 to $61.00 per barrel(14). This may reverse the trend of surplus supplies that began last year. It also may cause shortages(15).

3.6.2 Bentonite

The primary uses of bentonite are in drilling mud, foundry sand, Portland cement, filtrates, pond and reservoir sealing, and for pelletizing (iron ore). Wyoming, Montana, and California are the chief producers of high-swelling, or sodium, bentonites. Missouri, Pennsylvania, and Ohio are the chief producers of low-swelling, or calcium, bentonites(16).

The United States is a net exporter of all clays. The demand for all clays is expected to increase at an annual rate of between two percent and four percent through 1990. The United States position as a major supplier of clays is enhanced by the possession of more than adequate resources and the technology necessary to process large amounts of high-quality clays(17).

3.6.3 Zeolite

The uses and potential uses of zeolites include antibiotic and pesticide carriers, heat-storage systems, methane recovery systems, detergents, catalysts, hydrogen storage, and molecular sieves. The production of natural zeolite in the United States was estimated to have doubled in 1981, from 5,000 tons in 1980. About 4,000 tons were produced at Adrian, Oregon. The 1981 price of natural zeolites ranged from \$300.00 per ton to \$400.00 per ton, whereas the price of synthetic zeolites ranged from \$500.00 per ton to \$6,000.00 per ton. Supply and demand statistics are not readily available for this commodity. Production figures also are not well known. One 1981 estimate predicts that the natural zeolite market will exceed one billion dollars in the early 1990's(18, 19).

3.7 STRATEGIC AND CRITICAL MINERALS AND METALS

The North Fork Crooked River GRA is not favorable for any strategic or critical metals or minerals as listed in the BLM-supplied compilation given in Table 3-4 of TERRADATA's report entitled "Procedures for the Assessment of Geology, Energy, and Minerals (GEM) Resources."

4. CLASSIFICATION OF LAND FOR GEM RESOURCES POTENTIAL

The precise location of specific favorable environments within a given GRA depends upon three principal factors:

- The precision and specificity of avaliable data;
- The nature (size and spatial distribution) of anticipated deposits as predicted from known models; and
- The geometry of the favorable geologic environments.

Commodity-specific information in the North Fork Crooked River GRA is limited. Subsurface information is virtually non-existent. Therefore, the entire area, rather than specific subareas, has been classified for individual GEM resources (Figure 4-1 and Table 4-1).

The entire North Fork Crooked River GRA is highly favorable (Class 4C) for potential oil and gas resources because it is underlain by the appropriate geologic environment and is near known occurrences of this resource(8). There are oil shows and traces of gas in wells less that five miles from the study area. There also is an oil seep in a Jurassic limestone twenty miles east of the study area. The confidence level (C) signifies that the available data provide direct evidence, but that the evidence is quantitatively minimal to support the possible existence of this hydrocarbon resource.

The North Fork Crooked River GRA has a moderate favorability (Class 3) for the occurrence of bentonite and clinoptilolite deposits(6). These minerals are common alteration products in volcanic terranes. Deposits of clinoptilolite occur in Township 13S, Range 18E, and Township 10S, Range 25E in the John Day Formation. The confidence levels for the evaluation of these resource are A and B, respectively, because the GRA contains favorable rock-types for both bentonite and clinoptilolite, and there are known clinptilolite occurrences in nearby townships.

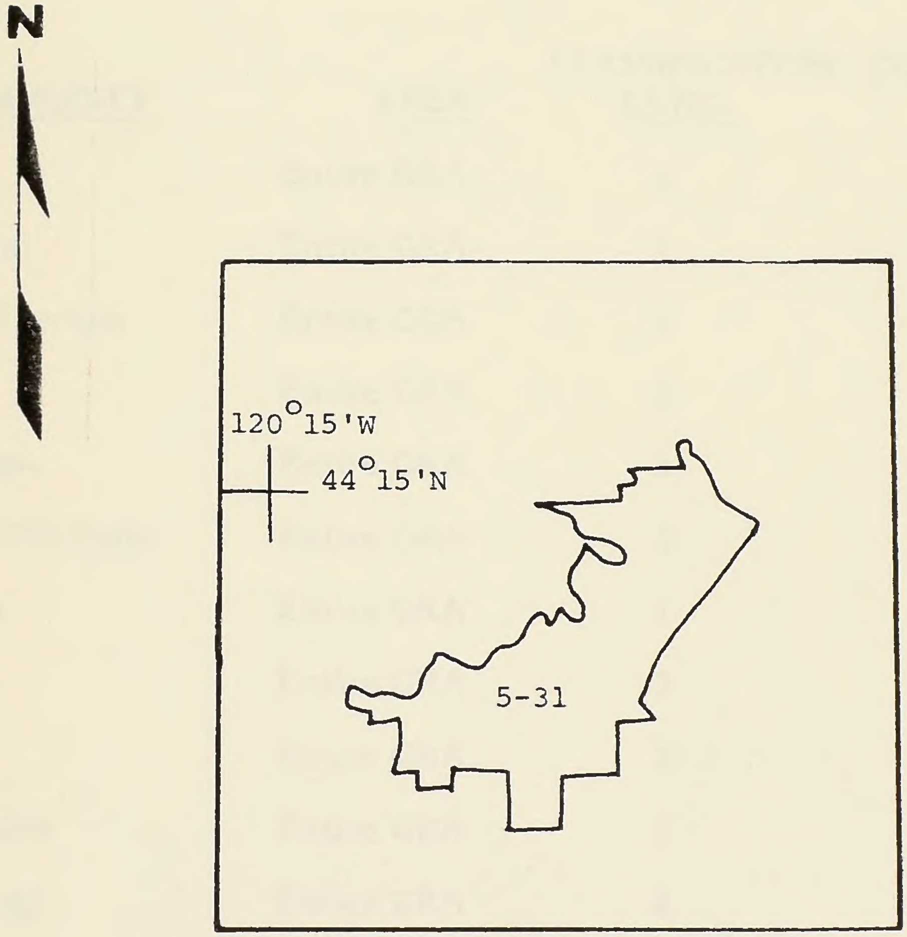
The North Fork Crooked River GRA has a low favorability (Class 2) for both diatomite and paleontological resources. Lacustrine environments of limited lateral extent that are potentially favorable for diatomite may occur throughout the Tertiary strata in the GRA. However, no diatomite occurrences are known to exist in the study area(6). Environments favorable for the occurrence and preservation of paleontological resources do not exist in the study area(7), even though the same rock units outside the GRA are fossilferous.

The North Fork Crooked River GRA is least favorable (Class 1) for metals and nonmetals(9), geothermal(11), uranium and thorium(12), coal(13), tar sands and oil shale(10), and limestone(6) resources because the geologic environments and the inferred geologic processes do not indicate favorability for the accumulation of these resources.

TERRADATA's evaluation of the North Fork Crooked River GRA is in agreement with the USGS evaluation of the area for the same leasable commodities.(20, 21, 22).

FIGURE 4-1

Land Classification Map
North Fork Crooked River GRA
(OR-050-12)
Crook County, Oregon



Scale 1:250,000
(Bend 1°x2° NTMS Quadrangle)

This map is an overlay for Figures 2-1 and 2-2.

Table 4-1

Classification Of Lands Within The
North Fork Crooked River GRA
(OR - 050 - 12)
Crook County, Oregon
For GEM Resource Potential

COMMODITY	AREA	CLASSIFICATION LEVEL	CONFIDENCE LEVEL	REMARKS
Metals	Entire GRA	1	B	
Geothermal	Entire GRA	1	C	
Uranium/Thorium	Entire GRA	1	A	
Coal	Entire GRA	1	B	
Oil and Gas	Entire GRA	4	C	
Tar Sands/Oil Shale	Entire GRA	1	C	
Limestone	Entire GRA	1	B	
Bentonite	Entire GRA	3	B	
Diatomite	Entire GRA	2	C	
Clinoptilolite	Entire GRA	3	A	
Paleontology	Entire GRA	2	C	
Hazards	See Hazards Map (GRA File)			
ESLs	None	1	C	

LEGEND:
Class 1 - Least Favorable
Class 2 - Low Favorability
Class 3 - Moderate Favorability
Class 4 - High Favorability

Confidence Level A - Insufficient data or no direct evidence
Confidence Level B - Indirect evidence available
Confidence Level C - Direct evidence but quantitatively minimal
Confidence Level D - Abundant direct and indirect evidence

5. RECOMMENDATIONS FOR FUTURE WORK

Further surface geologic investigations, including detailed mapping and stratigraphic studies, would enhance the confidence levels of many of the classifications in the North Fork Crooked River GRA. It is doubtful, however, that the original classifications would change substantially. Sub-surface investigations are probably not warranted in this area due to the costly nature of the available methodology. Geophysical and geochemical surveys might provide some insight into the potential resources of the study area. Geophyscial surveys might help to delineate structural traps for potential oil and gas resources.

- APPENDIX A -

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